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THE VEHICLE MONITORING SYSTEM AT WIDCO MINE

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THE VEHICLE MONITORING SYSTEM AT WIDCO MINE

by

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ABSTRACT

The WIDCO mine in Centralia, Washington was visited in July 1986. This report describes the mining system and Vehicle Monitoring System. The mining system is unique in this part of country, using bucket wheel excavator to remove overburden and shiftable conveyors to transport coal and waste material. The unique specially designed Stacker/Spreader machine unit is one of a kind.

The Vehicle Monitoring System was installed at the mine on two trucks and tested for one year. The system proved to be a useful maintenance and operations tool and further units were purchased.

The visit to the mine provided insight into the plan and procedures needed before a new system is introduced at a mine. The experience will be used during the similar test planned by CANMET and Gregg River Resources mine at their operations near Hinton, Alberta.

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SYSTÈME DE MONITORAGE DES VÉHICULES À LA MINE WIDCO

par

V. Srajer*

RÉSUMÉ

La mine WIDCO de Centralia dans l'État de Washington a fait l'objet d'une visite en juillet 1986. Le présent rapport contient une brève description du système minier et du système de monitorage des véhicules. Le système d'exploitation minière de cette mine est le seul du genre dans cette partie du pays. Il comprend entre autres l'utilisation d'excavateurs à godet pour enlever les morts-terrains et de convoyeurs ajustables pour transporter le charbon et les rebuts. On y trouve de plus, une machine empileuse/épandeuse spécialement conçue et unique en son genre.

Deux camions ont été équipés à la mine pour le système de monitorage et ces derniers ont fait l'objet d'essais pendant deux ans. Le système s'est avéré utile en tant qu'outil d'entretien et d'exploitation, et de nouvelles unités ont été achetées.

La visite de la mine a fourni un aperçu du genre de planification et de méthodes dont on a besoin avant d'introduire un nouveau système dans une mine. Cette expérience servira aux chercheurs du CANMET au cours d'essais semblables qui seront organisés à la mine Gregg River Resources près de Hinton en Alberta.

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INTRODUCTION

The Washington Irrigation and Development Company (WIDCO) was visited on July 15, 1986. The purpose of the visit was to see the Vehicle Monitoring System (VMS) in operation and to evaluate the user experience with the system. The VMS is a truck function's management system that collects and monitors certain operations of off-highway trucks at the mine. The VMS is also an intelligent warning system, a function selectable monitoring system for truck malfunction diagnostics, and a historical recording system for post-failure diagnostics and preventive maintenance trend analysis.

CANMET's Surface Mining Laboratory and Gregg River Resources Ltd. have commenced a joint project to test, monitor and evaluate the truck management system at their mine in Hinton, Alberta. The first part of the project was to select a suitable truck management system. The visit to WIDCO mine provided the opportunity to see a vehicle monitoring system in operation and to talk to the users of the system and compare their evaluation of the system with information received from the supplier, the GLI Corporation of Woodinville, Wa.

During the visit to the mine, a tour of the mining operation was arranged. In this report the mining system and mine operation are also discussed.

WIDCO MINE

GENERAL

The Widco mine is located on the outskirts of the town of Centralia in the State of Washington, within the Centralia-Chehalis coalfield. The main

seam, called the Big Seam (also known as "Big Dirty"), is on average 12 metres thick. All the mined coal is used by a local power generating station, owned by Washington Water Power Company.

The coal is sub-bituminous, having a heating value of 18 840 kJ/kg with less than 0.5 % of sulphur. The mine's annual production is 5.1 Mt of ROM thermal coal.

The geology of the Centralia-Chehalis field is complex, with much faulting. The dip of the coal seam within the mine area ranges from 8 to 16 degrees, having an average of 10 degrees. Overall coal thickness is fairly consistent.

The coal reserves within the mine boundary are estimated to be close to 200 Mt of recoverable coal. The coal seam contains large boulders and lenses of hard material that must be removed separately. The overburden is on average 76 m deep, waste to coal ratio is 7:1. About 80 ha of mine area is disturbed on yearly basis. The mine operates 7 days/week, 3 shifts/day.

Water handling and treatment are major problems at this operation. High rainfall and frequent storms necessitate efficient erosion control. On reclaimed areas, gradient terraces sloped at 1 % are used to carry runoff to rock lined channels and to the ponds. A two-step flocculation system is used to remove colloidal clays and so far has been successful in achieving the required water quality.

MINING SYSTEM

The top of 36 m of overburden is removed by the bucket wheel excavator Type Sch Rs [1940/0.5 * 14] with belt wagon Type BRs [1400/(37+43)*11.5], manufactured by Demag-Lauchhammer of Germany. The remaining 40 m or so is excavated by a Bucyrus-Erie dragline that uncovers the coal seam. The dragline is currently operating on an extended bench sequence that necessitates between 75 and 100 % rehandle of the material.

The bucket wheel excavator's conveyor system is illustrated on Fig.1, a section through the benches looking north is shown on Fig.2 (1). The overburden is transferred to a conveyor by means of a bandwagon, apparent in Fig.2. The operation involves taking a preliminary cut to establish a bench, and then using a ramp to take Cuts 1 and 2. The BWE is then backed off and the lower Cuts 3 and 4 are taken.

The BWE has a 12.2 m diameter wheel, with eight digging buckets of 1.3 m³ capacity. The unit has a digging height of 12 m above the base. The 182 cm wide, boom discharge conveyor is designed to remove 3,800 m³/hr of material. The speed of the conveyor belt is 305 m/min. The upper section has independent slewing of both the digging wheel boom and the discharge conveyor. The lower section is crawler mounted. The crawlers exert a soil bearing pressure of 2.9 kPa during operation, and are capable of propelling at 6.1 m/min. The BWE discharges material directly in a receiving hopper located on the loading boom of the mobile transfer conveyor, called a bandwagon. The reach of the bandwagon from end-to-end of the pulley center lines is 79.2 m, and each boom can be raised to a 14.6 m lift. The bandwagon is supported on a crawler-mounted, slewing framework. The bandwagon feeds the material to the shiftable conveyor. Two shiftable conveyors (Nos. 1 and 3) are placed in a north-south direction, and are connected with an extendable cross conveyor (No.2), that is over 1.5 km long. About 36 m of overburden is stripped by the bucket wheel at conveyor No.1 in two stages, and the material is transported to conveyor No.3, where self propelled, crawler-mounted stacker is used for spreading the spoil material. Conveyor No.1 is shifted periodically to the east to keep up with the overburden excavation. The conveyor No.3 is shifted in east direction too, but less frequently.

The stacker, equipped with a 1.5 m wide conveyor belt and a 61 m boom reach having a 11.6 m maximum boom lift, can handle 4 800 m³ per hour. This works out to be about 7 600 t/hr, which meets the shiftable conveyors capacity. The general view of the mine is illustrated on Fig.3, showing the operating BWE in background. A close view of the BWE digging on the upper bench is shown on Fig.4.

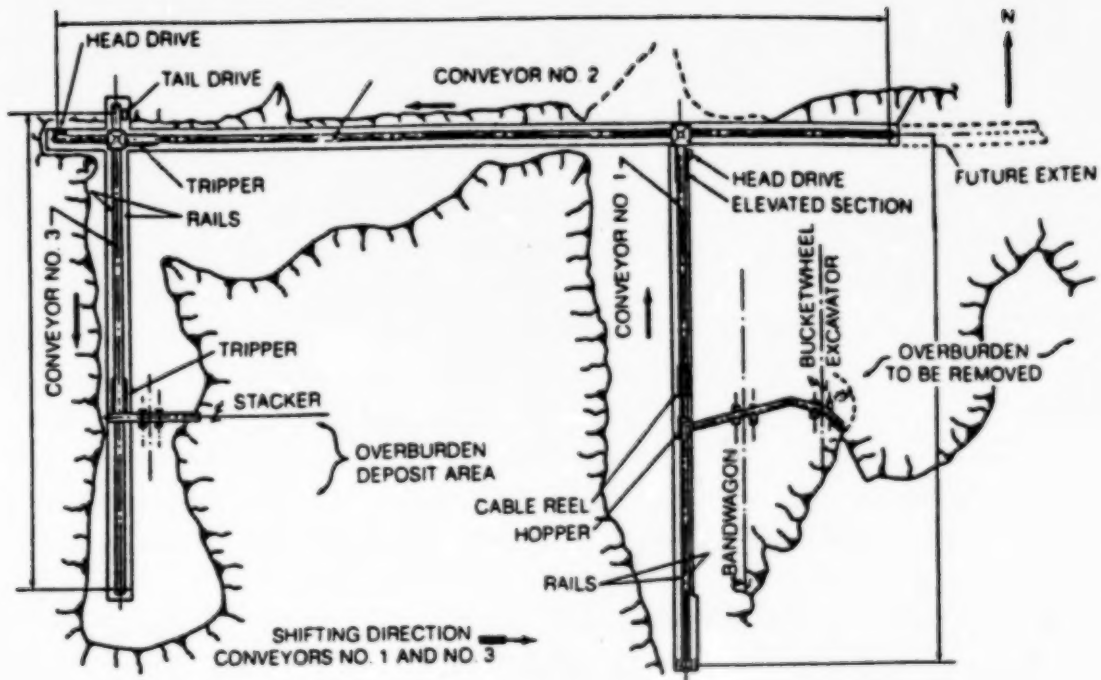


Fig. 1 - Shiftable Conveyor Arrangement(1)

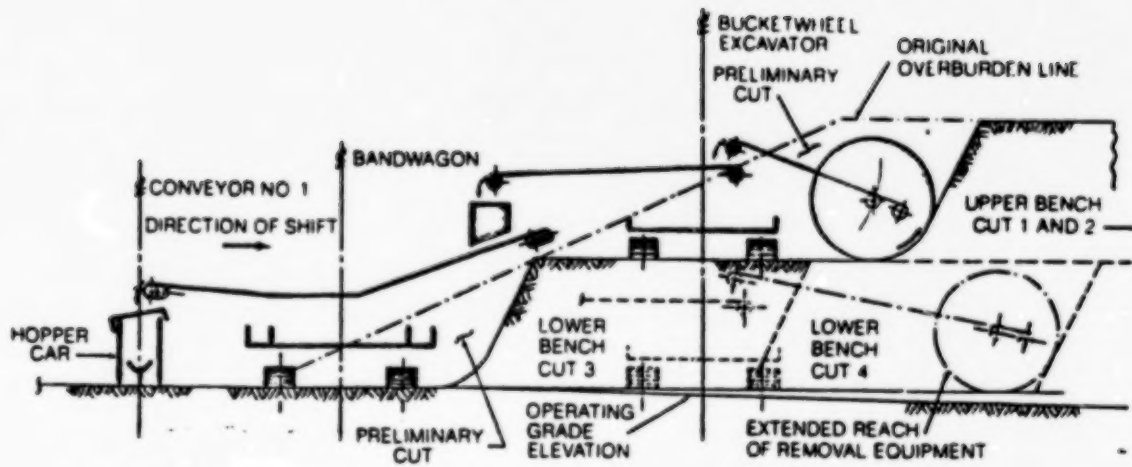


Fig. 2 - Section Thru Benches(1)



Fig. 3 - General View of the Pit

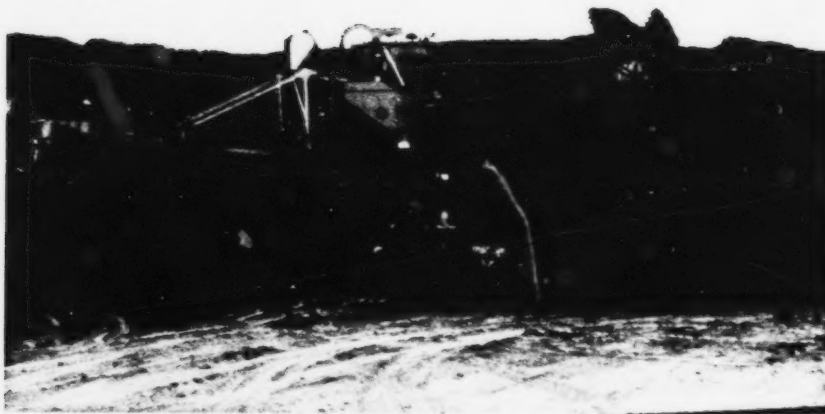


Fig. 4 - Bwe Cutting at Upper Bench

Coal is broken for loading with a Cat D-9 bulldozer equipped with a Kelly ripper. Because the mine is advancing diagonally down the 10 to 20 degree dip of the coal, haulage was ramped 640 m out of the lower end of the pit at an average grade of 6 degrees. The central haulage ramp is maintained by mining alternate sides of the property. This technique reduces the length of each dragline cut and subsequent deadheading time.

A novel movable conveyor/spreader scheme was introduced to the mine's coal storage area in 1979. The system, designed by RAHCO of Spokane, Wa. and sponsored by the U.S. Department of the Interior, Bureau of Mines in Spokane, is a rotary excavator-mobile conveyor-reclaimer unit. The system represents a completely new approach to continuous material handling systems. The long conveyor may be repositioned with a single command in just a few minutes. Automatic sensors direct each section of the conveyor to the new position without further commands. A self-levelling feature permits the frame to remain level as it moves over coal storage site. This arrangement make it also possible to take a shallow strip cut of the coal storage pile and transfer this material outside of the storage, to the coal processing plant, or to the power plant. This arrangement eliminates the need for underground storage facility loadout of coal. The RAHCO's mobile conveyor at the power plant coal storage site is shown on Fig.5. The bucket wheel reclaimer feeding coal onto the mobile conveyor unit is illustrated on Fig.6. The stacker/spreader machine unit is also illustrated in Fig.7, courtesy of RAHCO, Inc., of Spokane, Wa.

VEHICLE MONITORING SYSTEM

SYSTEM OPERATING MODES

The Vehicle Monitor System (VMS) is a multi-function system that serves as an intelligent warning system for the truck operator. It also provides truck malfunction diagnostics and historical post-failure diagnostics for maintenance personnel. The system, installed at Widco mine was custom



Fig. 5 - RAHCO's Movable Conveyor/Spreader

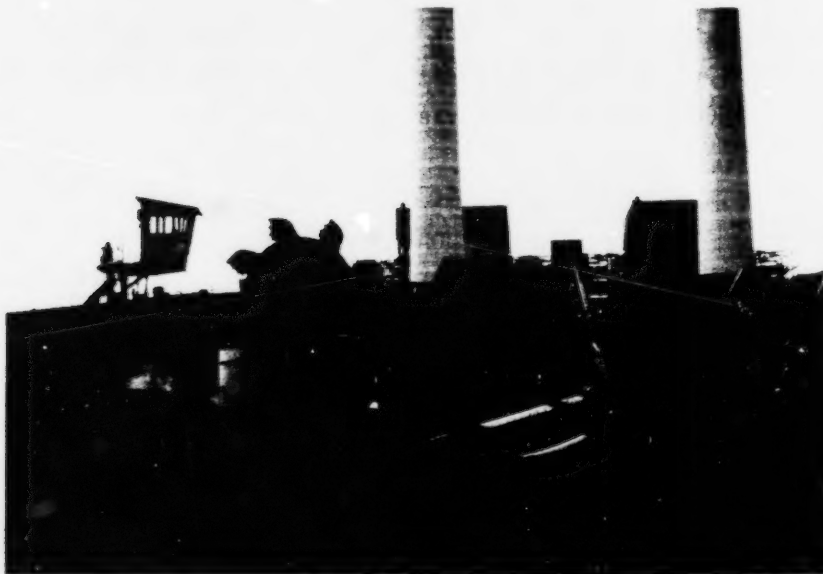


Fig. 6 - Reclaimer Feeding RAHCO's Spreader

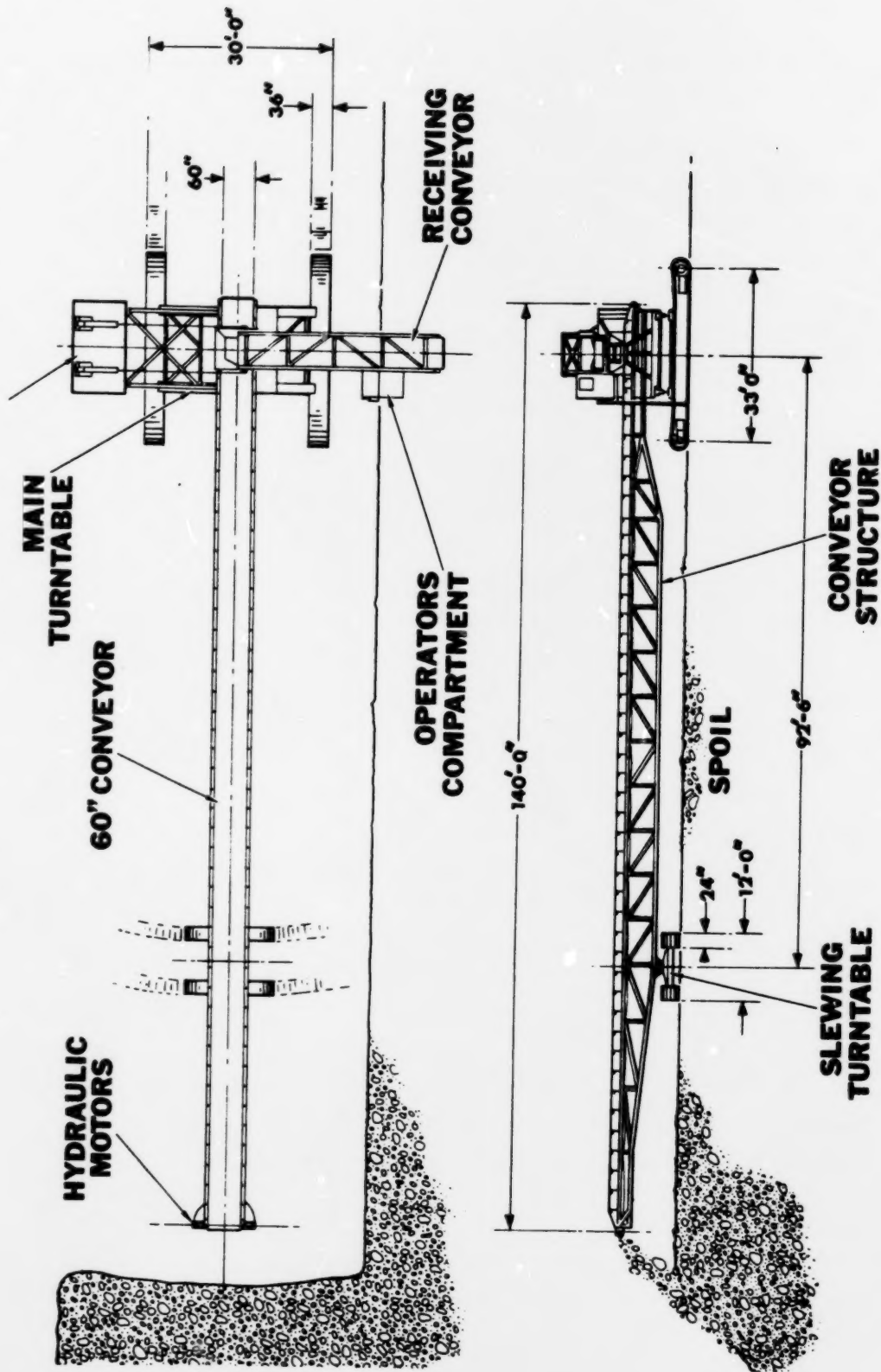


Fig. 7 - The Stacker/Spreader Machine Unit (Courtesy of RAHCO, Inc.)

tailored to Euclid R-100, Cat 777 and Cat 776 mine haul trucks, which are used at the mine.

The VMS performs several self-tests during its initialization. Any deviation from the routine operation is diagnosed as an internal problem of the system, that must be fixed before actual monitoring commences. The most important verification is the testing of the on-line computer and alarm horn. It is imperative that the self-test cycle be observed and proper operation be verified at each system startup.

The following is a list of system operating modes, followed by the mode functional description:

Alarm Mode.

In this mode if no alarm condition exists, only RPM is displayed and the test switch is non-operational. If an alarm condition exists, red flashing can be observed at function indicator (LED). An appropriate message on an illuminated liquid crystal (LCD) is displayed and the audible alarm will sound. The alarm is set up in three ways, depending on the severity of the cause:

1. Super critical

Audible alarm and LCD will flash "STOP".

(Example may be change in crankcase or engine oil pressure).

2. Critical

LED's flashing, LCD display "STOP", and the audible alarm will alternate for five seconds on and off.

(Example may be increase in engine oil temperature).

3. Non-critical.

Appropriate LED's will flash, LCD will indicate the value of the out of condition parameter, and the audible alarm will cycle the same as critical except after the third cycle will be silenced. This alarm indicate to the driver that some function needs servicing.

Test Mode.

In the Test Mode the real time values of monitored functions are made available to maintenance personnel. Pushing the "TEST MODE" button will cause the system to step into monitored function and display the associated real time value on the LCD.

Memory Mode.

In the Memory Mode the function historical data are made available as a maintenance diagnostic aid. All historical data are stored in a non-volatile memory.

STANDARD FUNCTIONS

Engine RPM-Overspeed.

The engine RPM is critical for all VMS internal operation. The system is programmed not to activate until the engine is started and transient functions such as oil pressure have had time to settle out. The oil pressure and air filter alarm levels are RPM dependent. Certain function alarms are keyed to RPM levels, such as "Air filter open" will not alarm below 1600 RPM. If RPM drops below 450 it is assumed the engine has been shut down. The RPM is measured by a magnetic sensor to detect rate of rotation of the flywheel or a related gear.

Snap Acceleration.

The VMS is set to measure the time required for the engine to accelerate from 800 to 1800 RPM. If this time is compared to a previous measurement or to a known valid value for the engine type, the amount of variance will serve as an indicator of engine performance degradation.

To perform a "Snap Test", the engine and transmission must be at operating temperature and idle. The RPM has to be below 800.

Engine Oil Level.

The system will record the total time since the last reset that the engine has been run with oil level in alarm mode. The oil level sensor is installed in the oil pan slightly below the "add oil" level. A critical alarm is provided to the vehicle operator if the oil level drops below this sensor.

Engine Oil Pressure.

The long term decreasing oil pressure as compared to RPM is indicative of engine wear and may be forewarning of more severe problems.

Instantaneous loss of oil pressure indicates imminent destruction of the engine. A critical alarm is provided if pressure drops below an RPM related limit curve which is characteristic to engine type.

Engine Coolant Level.

A level sensor is installed in the upper radiator reservoir. If coolant level falls below the level of the sensor, the critical alarm is provided. The coolant level may be also reset to indicate "High" at the LCD and will remain in this state until a low coolant indication is sensed. It will then switch to "Low" and remain there until the next reset.

Engine Coolant Temperature.

The coolant temperature sensor is installed in the engine water jacket. If the temperature of the engine coolant exceeds 212 degree F, the critical alarm is provided. A 20 second delay is programmed into the alarm criteria to guard against irrelevant short duration transients.

Crankcase Pressure

If the pressure in the crankcase falls to below 6 psi for Cummins and DDAD engines and below 4 psi for Cat engines, the critical alarm is provided to the operator.

Air Filter Restriction.

The incoming combustion air supply on a diesel engine must be filtered to remove abrasive particles. If the duct between the filter and turbo is holed, the resulting contamination will cause destruction of the engine. If the filters should become clogged, the engine will be starved for air and efficiency will be affected. The VMS system provides protection for the engine for both anomalies.

The pressure drop at the filter is monitored and compared to a set of RPM - related limits. If the pressure is below the lower limit for an engine, it is assumed there is a defective filter and the non-critical alarm will be provided to the vehicle operator.

MPH (KPH)

The rear axle RPM is monitored on transmission drive trucks, scaled down to indicate an approximation of MPH. An alarm is activated if the truck exceeds 38 MPH which is considered a maximum safe operating speed.

Engine Oil Temperature

A sensor is installed in the engine oil system. If the temperature exceeds 240 degree F the non-critical alarm is provided to the operator.

Battery Voltage

The VMS monitors battery voltage and provides an alarm if the voltage drops below 18 Volts.

OPTIONAL FUNCTIONS.

The VMS has been designed to monitor several additional truck parameters which have been determined by WIDCO to be beneficial to their operation. The following functions are monitored at the mine:

Hydraulic Oil Level

The hydraulic oil level is monitored on the Cat trucks only. The level sensor is installed in the reservoir below the low oil level. If the level drops below this sensor, the non-critical alarm is provided.

Transmission Oil Level

The transmission oil level is monitored on the Euclid trucks only. The level sensor is installed in the transmission oil reservoir below the low oil level, providing non-critical alarm to the operator if the level of oil drops below this level.

Brake Pressure

The brake pressure of the Cat trucks are monitored only, because with this type of the truck, if the system losses pressure, the spring loaded

brakes will drag, resulting in destruction of the pads and rotors. If the pressure drops below 450 psi in the brake piping system, the non-critical alarm is provided to the operator.

The mine also started recently to monitor brake pressure of the Euclid trucks, as a diagnostic aid. A meaningful alarm criteria for this system has not yet been defined, therefore no alarm is provided.

Hydraulic Hoist Pressure

The pressure sensor is installed in the piping for the system, providing a troubleshooting aid to the maintenance personnel. No alarm system is installed.

Hydraulic Oil Temperature

The sensor is installed in the hydraulic reservoir of the Euclid trucks. If the temperature exceeds 240 degrees F the non-critical alarm is provided.

Transmission Oil Temperature

The temperature sensor is installed in the transmission system of the Cat trucks only. It works on the same principle as the hydraulic oil temperature sensor.

EXPERIENCE WITH THE SYSTEM.

The WIDCO mine has a long history of being one of the few mines with progressive management that will not hesitate to test new ideas and introduce new technology at the mine site. The VMS is just one example of successful implementation of new technology that may reduce operating cost and improve productivity.

The VMS was initially installed on three trucks and run for 12 months on a test basis. The system proved to be reliable and functional, as described. The supplier, GLI Corporation, provided extensive support to the mine management and maintenance personnel during the testing period. After initial testing, an order was placed for 22 additional units to be installed on Euclid and Cat trucks (2). This will provide complete coverage of the whole fleet. The system will be supplied virtually with no change in original design or specification. The only change requested by the mine is better moisture protection of the sensors. New seal were developed to satisfy this requirement. The original seal was working quite properly during rain but developed problems when trucks were pressure washed.

One man (maintenance supervisor) was permanently assigned to be in-charge of the VMS, to monitor its performance, to provide testing and to report on problems with the system. The supplier visited the site on monthly basis, or when requested. On average, the system worked perfectly 86 % of the time. Only 4 % of the time was lost because of manufacturers problems. Mine related problems accounted for the rest (3).

CONCLUSION

The visit to the WIDCO mine proved to be useful, because this is the only mine that is testing one of the Truck Management Systems, available for surface mines. The experience gained during the visit will be applied to cooperative demonstration project with Gregg River Resources this fall where the OBDAS system is planned to be tested.

Overall, the VMS, as seen at the WIDCO mine, proved to be a flexible system for mine maintenance, tailored to specific equipment and operating conditions. By monitoring vehicle operation parameters, the early warning and fault detection capability of the system allows the operators and maintenance personnel to prevent breakdowns or detect problems before they results in costly damage.

The VMS is a preventive maintenance tool only, no other functions are monitored. It is not tailored to measure vehicle performance or to directly improve productivity of the fleet. It is installed to reduce downtime and repair cost. On-board memory storage allows engine and operating data to be stored for later analysis. This data can also be transferred to a central computer facility; something the mine maintenance personnel are planning after the initial system is fully tested. The increased vehicle life, improved truck availability and lower maintenance and operating costs, are expected to pay for the system in two months of operating time (2).

The system benefit is seen in safe operation - the operator is not distracted from his primary task - when the problem occurs, he is told specifically the nature of the problem and what action to take.

ACKNOWLEDGEMENT

The author likes to express his gratitude to Mr.E.Frizzell of the U.S.Bureau of Mines in Spokane, Wash. for arranging this visit, and to the mine engineering and maintenance personnel of the WIDCO mine in Centralia, Wash. for the tour of the operation and providing the information about the VMS system.

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